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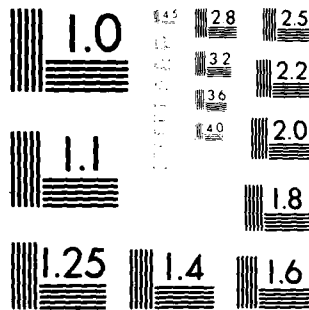
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RESEARCH ON NEAR FIELD PATTERN EFFECTS
(Final Report)

The Ohio State University

W. D. Burnside and N. Wang

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The Ohio State University

ElectroScience Laboratory

Department of Electrical Engineering
Columbus, Ohio 43212

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This report is a summary of the research accomplishments achieved during the present contract period. Our main objective has been to develop an efficient numerical solution to compute the near as well as far field radiation patterns for an antenna mounted on a prolate spheroid. Note that the prolate spheroid will be used in the future to simulate the fuselage of a general aircraft. The uniform Geometrical Theory of Diffraction solutions which were developed previously were		

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used to analyze the radiation from the prolate spheroid; however they require one to identify the appropriate geodesic paths. These geodesic paths indicate the flow of energy as it propagates around the spheroid. Using a cone perturbation model, an efficient numerical solution for the geodesic paths and the associated radiation patterns has been obtained. This solution was also extended to analyze the scattering from a finite flat plate which was illuminated by energy propagating around the spheroid. However, the flat plate can not be any closer than a few wavelengths to the spheroid. This shortcoming will be corrected in the near future.

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I. INTRODUCTION

This general research effort has concentrated on the development of analytic tools necessary for one to accurately predict the radiation patterns of antennas mounted on aircraft. This year's effort has involved the development of efficient high frequency radiation solutions for an antenna mounted on a prolate spheroid. Note that the prolate spheroid will be used later to simulate the fuselage of a general aircraft. The general uniform Geometrical Theory of Diffraction (GTD) solutions [1] which are applied here were partially developed under a previous contract with the Naval Air System Command (NASC). These GTD solutions provide a means to compute the near as well as far field radiation patterns for an arbitrary antenna mounted on a general convex curved surface; however, they are based on a complete knowledge of the geodesic paths associated with the curved surface on which the antenna is mounted. Since geodesic paths are not, in general, easily computed, one must develop new techniques which efficiently evaluate them for the curved surfaces being studied. In this case, the prolate spheroid is under investigation in that it is a three-dimensional structure which can be used to simulate a wide variety of aircraft fuselages.

An efficient near and far field radiation solution for an antenna mounted on a general convex curved surface is the key to the development of a useful general analysis of airborne antenna patterns. This becomes apparent once one realizes that the scattering associated with aircraft structures such as wings, stabilizers, etc. is dependent on the field incident on them. In that one can simulate the aircraft structures other than the fuselage by finite flat plates [2,3], one can directly predict their scattered field from such structures using GTD once the incident field is known. With this in mind, the need for an efficient radiation solution for an antenna mounted on a prolate spheroid is rather obvious.

In that the general GTD solutions are inherently efficient, our main thrust this year has concentrated on the development of efficient geodesic solutions for antennas mounted on a prolate spheroid. Note that this involves the development of both a near and far field pattern solution which will in turn affect the geodesic solution. The near field is needed in order to determine the field incident on the finite flat plates which are in close proximity to the spheroid. In addition, the near field patterns for airborne antennas are highly desirable in terms of experimental verification. Through the years of studying the development of airborne antenna pattern prediction techniques, it has become apparent that experimental patterns are more efficient to take in the near field. This might be done using a scale model aircraft and taking the patterns in a fixed range anechoic chamber. For many years there have been concerns that the near field pattern effects associated with such measurements were too difficult to overcome such that they forced many antenna designers to use far field outdoor ranges. As presented in Reference [4], it is our contention that one can verify our numerical results at any convenient range and, then, simply have the numerical solution provide the desired far field pattern. This approach should receive a great deal of attention in that one can take whatever measurements he can in order to efficiently verify the simulation accuracy of the numerical solution. Once the simulation is complete, the numerical solution can provide very efficiently all the pattern information to evaluate the airborne antenna system's performance. Note that it is our goal to be able to compute a complete conical pattern cut in approximately one minute using a high speed digital computer. It is felt that this objective is necessary in order to provide the necessary tools to allow the antenna designer to make appropriate and efficient judgements about the complete radiation system.

II. TECHNICAL ACHIEVEMENTS

Our main research objective under the present contract has been to develop efficient solutions for the geodesic paths associated with the prolate spheroid. The need for such solutions was presented in the previous section. Various exact geodesic solutions were previously examined in Reference [5] in terms of a set of differential equations obtained using tensor analysis and an integral equation using calculus of variations. Both of those solutions were found to be very inefficient and, consequently, not appropriate for this application. Since the exact solutions could not be applied directly, various approximate solutions were studied. After recognizing that there was only a small significant region around the antenna location where the geodesic paths were needed, it was found that one could use a cone perturbation model to simulate the prolate spheroid as shown in Figure 1. In that the geodesics associated with the cone are straight lines on the unfolded surface as shown in Figure 2, it was felt that one could slightly distort the cone along its axis and still maintain a simplistic solution for the geodesic paths on the prolate spheroid. Such a solution was developed for the far field radiation patterns as presented in Reference [6]. That solution was extended in Reference [7] to compute the complete near field patterns. Note that the near field solution here implies the solution is valid in the near field of the prolate; i.e. it is not valid in the near field of the antenna. These solutions were verified in terms of comparisons with experimental results for a monopole mounted on a prolate spheroid. Some examples of these comparisons are shown in Figure 3. Note that many more results can be found in References [6,7].

With the near and far zone radiation solutions complete for antennas mounted on a prolate spheroid, our next concern was the scattering associated with the finite flat plate structures which were illuminated by energy propagating around the spheroid. This aspect of our research effort involves two basic questions: 1) is the previous spheroid solution

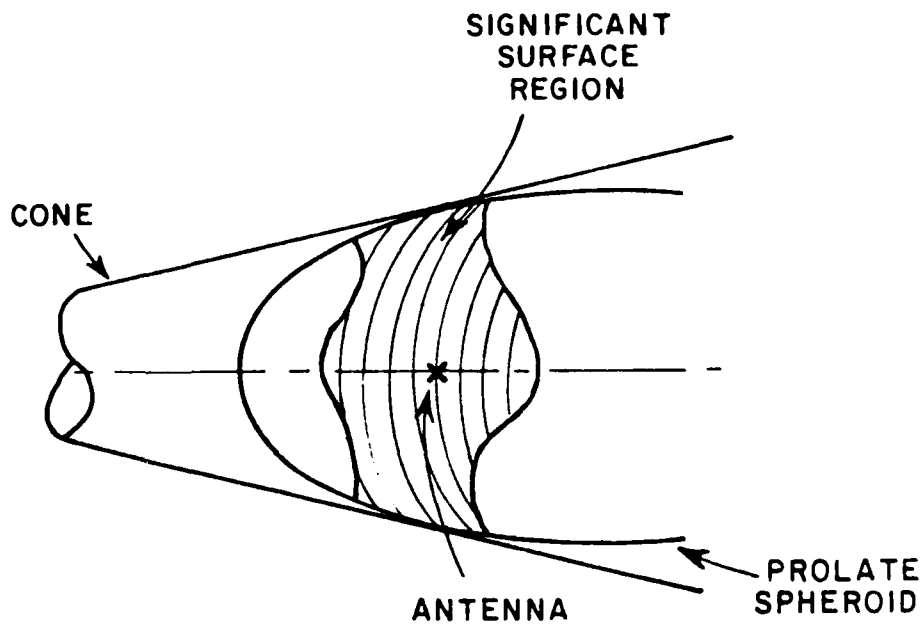


Figure 1a. Cone simulation.

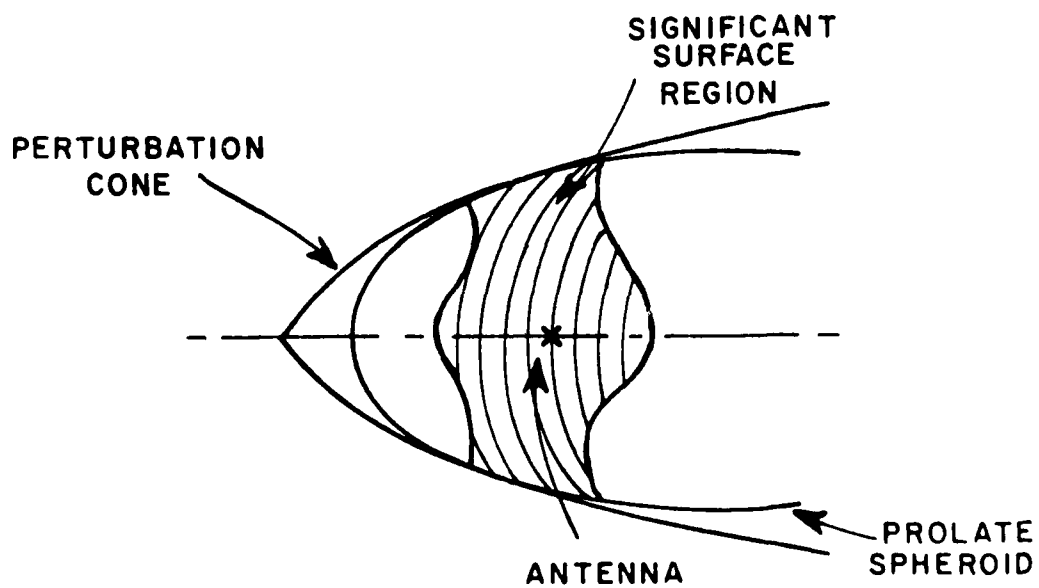


Figure 1b. Cone perturbation model.

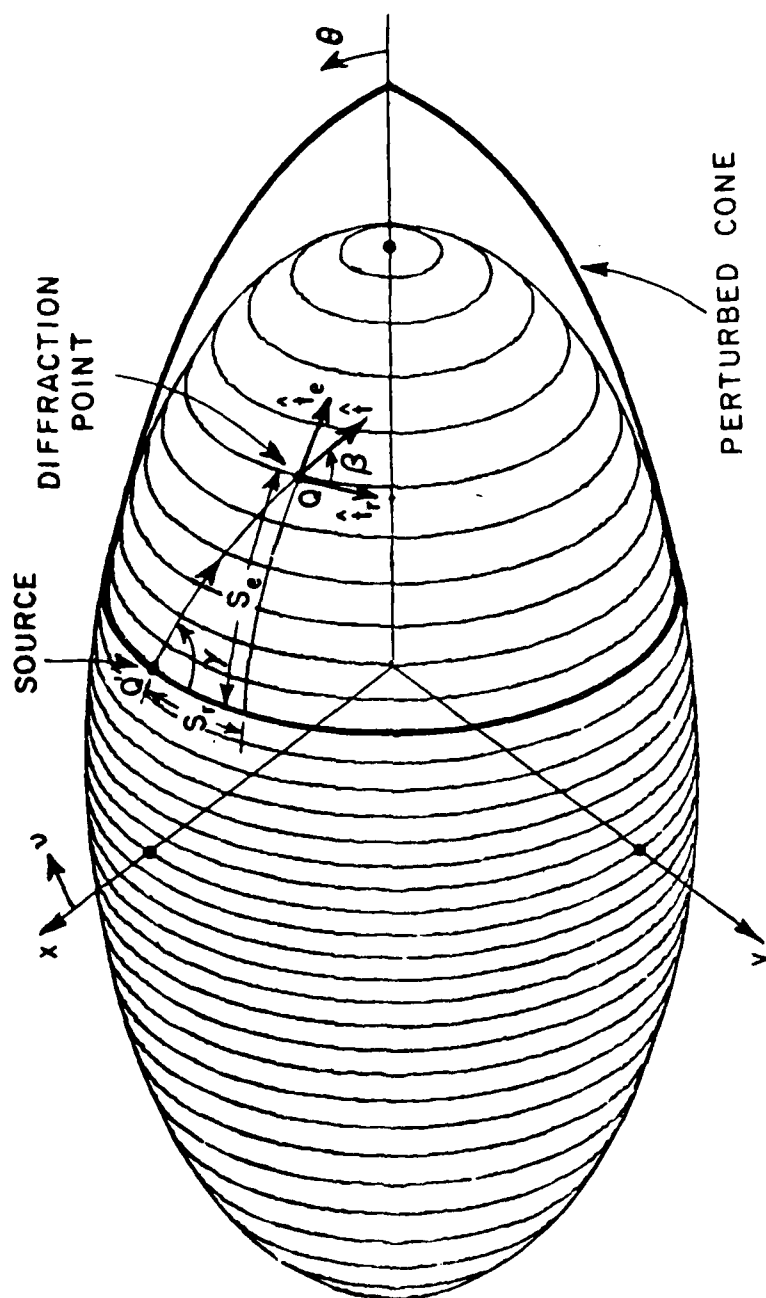


Figure 2a. Geodesic path on the perturbed cone.

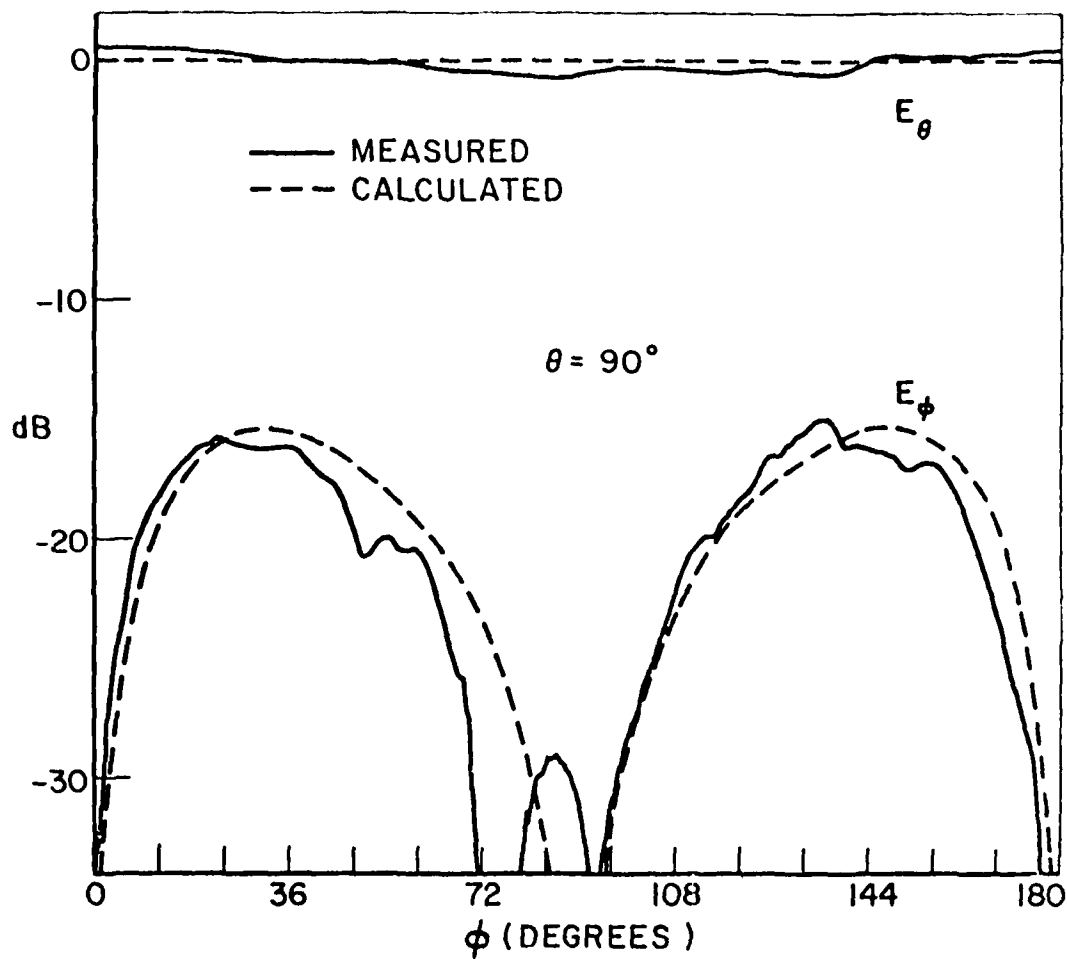


Figure 3a. Azimuth plane patterns for a short monopole mounted at the center of a $2\lambda \times 4\lambda$ spheroid.

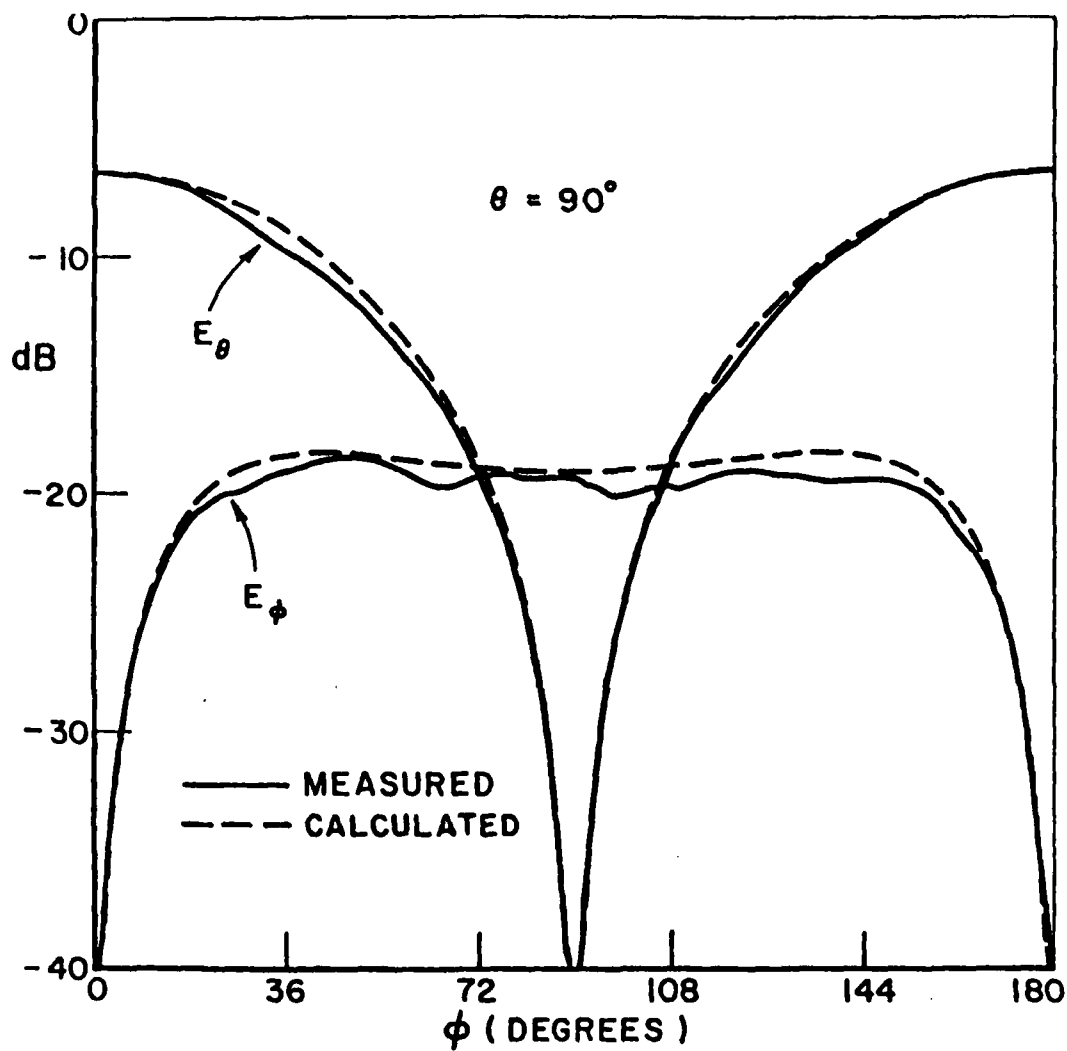


Figure 3b. Azimuth plane patterns for a circumferential slot mounted at the center of a $2\lambda \times 4\lambda$ spheroid.

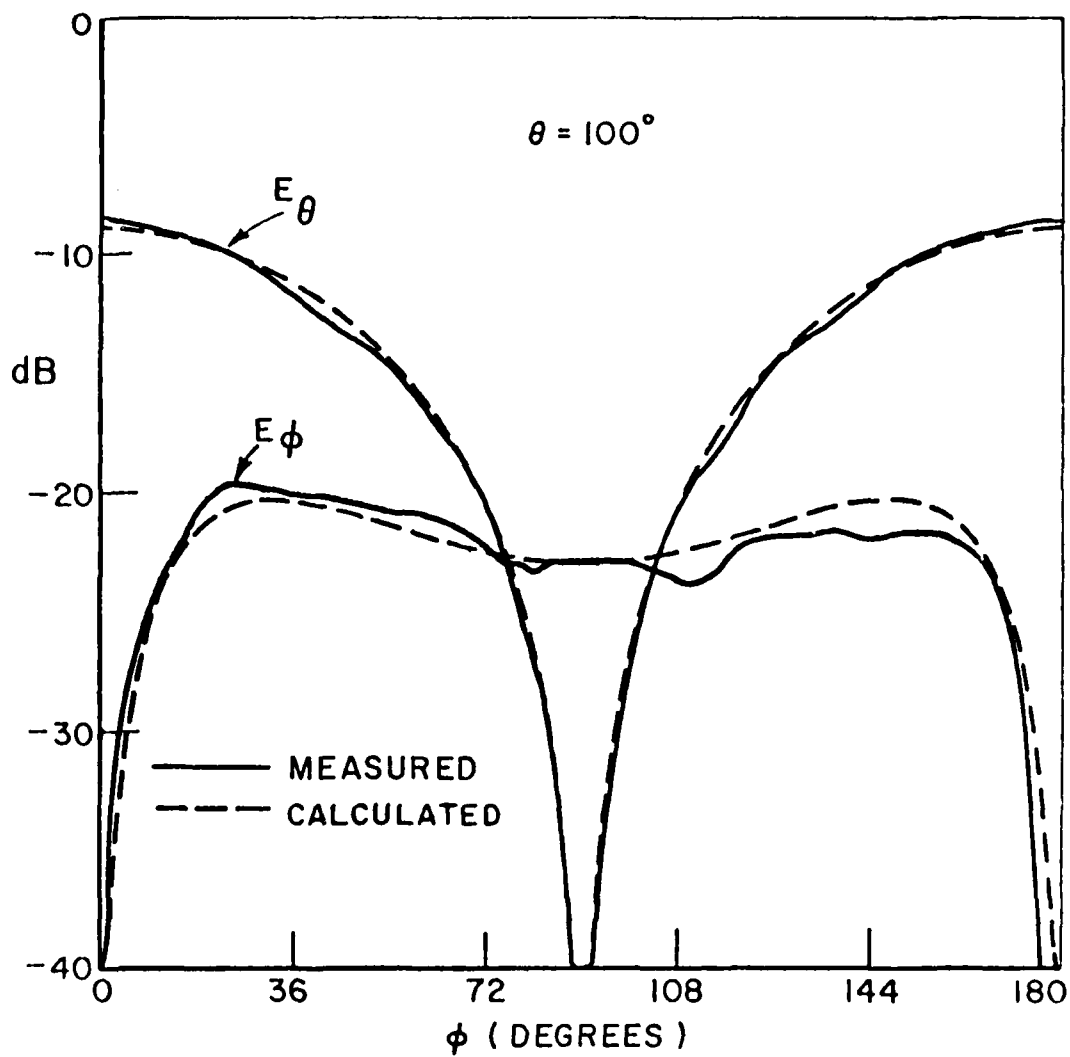


Figure 3c. Conical patterns about the vertical for a circumferential slot mounted at the center of a $2\lambda \times 4\lambda$ spheroid.

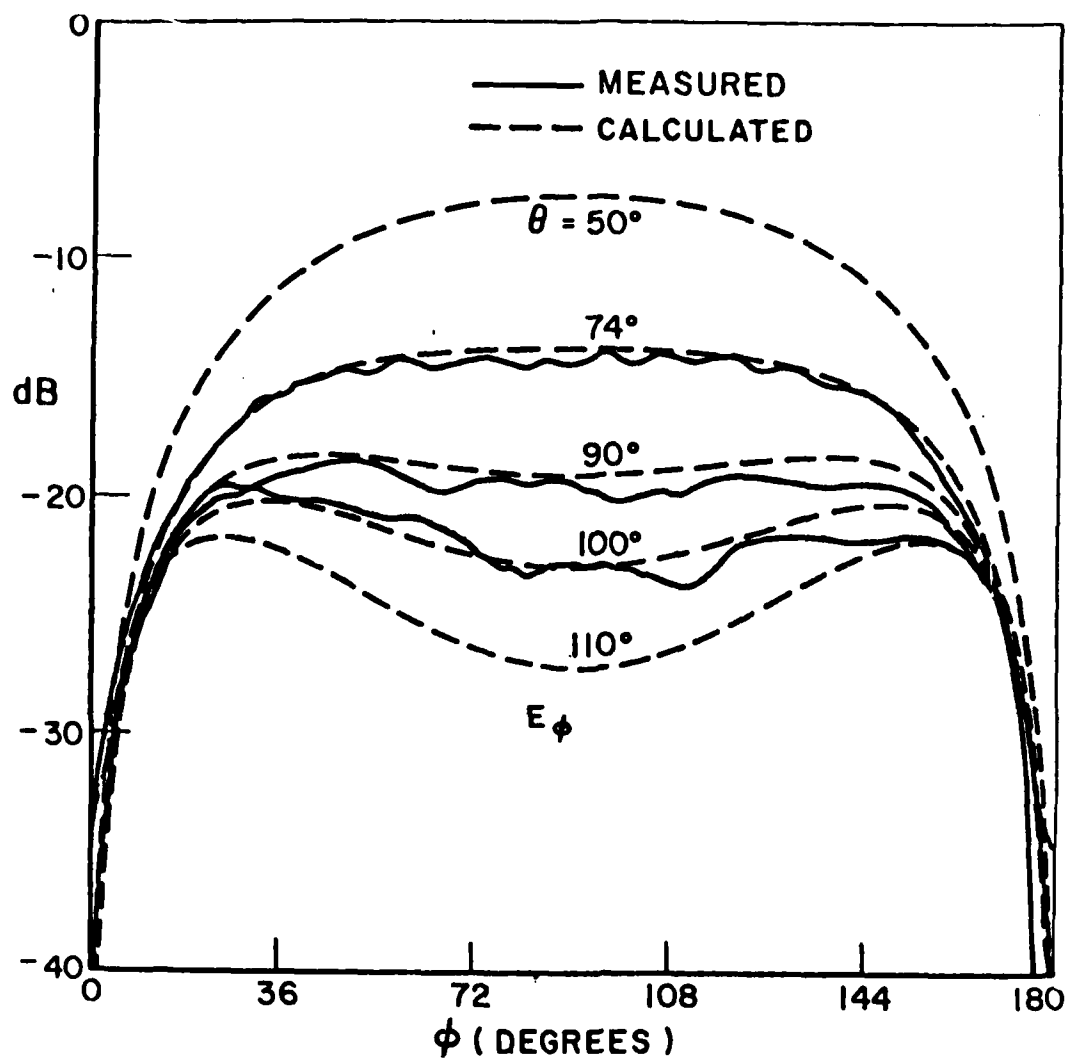


Figure 3d. Conical patterns (E_ϕ) about the vertical for a circumferential slot mounted at the center of a $2\lambda \times 4\lambda$ spheroid.

accurate enough to predict the plate scattered fields, 2) and if so, how efficient is it? Both of these questions were addressed in detail and resolved under the present contract. It was found that our previous prolate spheroid solution did provide the necessary accuracy to predict the plate scattered field. However, using it directly resulted in excessive computational times especially in terms of the diffractions associated with the edges and corners of the plates. After thoroughly examining this problem, it was concluded that the only alternative to reduce the diffracted field computation time was to store more information. Before examining the details of this storage solution, one should realize that this modification has required a major change in our basic computer programming philosophy in that our previous codes were both efficient in terms of computation time and computer storage resources. With this storage modification, our new numerical solution will remain computationally efficient; however, large storage capability is required if one wishes to treat aircraft simulations involving many finite flat plates. If just a few plates are used, the storage requirements are minimal.

The inefficiency associated with the diffracted field routine was directly related to the determination of the field incident on the diffracting edges. Realizing that the field incident on the edge is independent of the receiver location, one can, then, store the field incident along each of the plate edges at selected points. Because the phase of the incident field varies excessively along the edge, one cannot directly store the incident field. However, all the parameters associated with the incident field computation can be stored such that one can simply use linear interpolation to determine the field incident at any point along a given edge as shown in Reference [8].

A complete computer program was developed around the previous solutions which provided the radiation patterns for an antenna mounted on a prolate spheroid with a finite flat plate in close proximity. An example of the accuracy of that solution is shown in Figure 4. Note that this solution is only valid provided the flat plate does not come

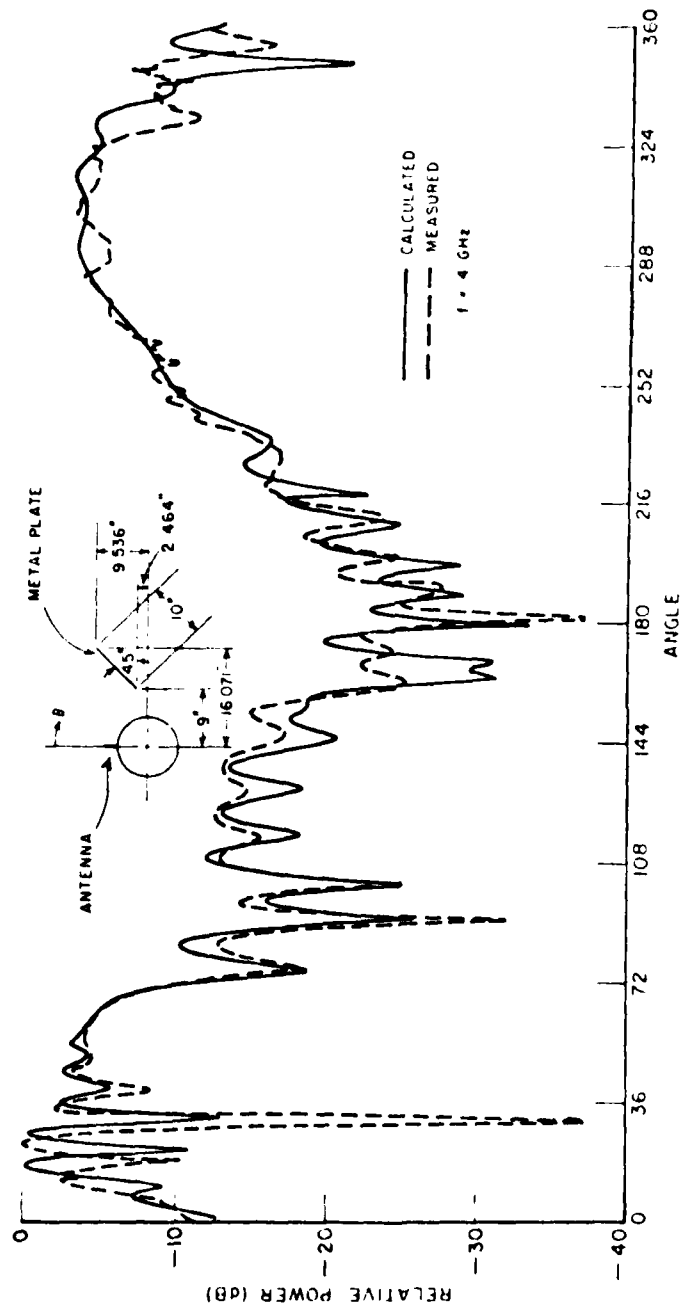


Figure 4. Comparison of measured and calculated near field roll plane patterns. The receiver was 36" from the spheroid origin. The pattern was measured at 4 GHz using a spheroid 24" long and 1.2" wide.

too close to the spheroid, i.e. no closer than a few wavelengths. The plate cannot come in contact with the spheroid in that the plate-spheroid junction edge and associated diffractions are not completely understood. The development of the complete code including the analysis of the junction edge diffracted fields is the main topic of our forthcoming contract.

III. CONCLUSIONS

Under the present contract, the complete numerical solutions for the near as well as far field radiation patterns for an antenna mounted on a prolate spheroid has been developed. These solutions are based on the high frequency uniform Geometrical Theory of Diffraction (GTD) expressions [1] partially developed under our previous contract with the Naval Air System Command (NASC). The significance of these numerical solutions is associated with the development of extremely efficient methods to compute the geodesic paths associated with the prolate spheroid. The accuracy of this efficient GTD solution has been verified in terms of numerous comparisons with experimental results.

These solutions would not be as significant if they could not be applied to analyze the scattering from finite flat plates. Note that the flat plates will be used in the future to simulate various aircraft structures [2,3] such as wings, stabilizers, etc. In order to ascertain the applicability of these solutions in this regard, a computer program was developed to analyze the plate scattering effects when it was illuminated by energy which propagates around the prolate spheroid. It was found that these solutions were accurate in this application when compared with experimental results. However, the direct application of these solutions was found to be rather inefficient due to the excessive time necessary to compute the field incident on the attracting edge. This problem was solved by storing the appropriate parameters associated with incident field at selected points along each of the plate edges. This solution was, then, verified by comparisons

with experimental results. Note that additional accuracy checks will be made as the aircraft code results are compared with actual scale model aircraft measurements. To date it has only been verified that the scattered fields solutions are valid and efficient provided the plates are removed from the spheroid, i.e., at least a few wavelengths.

It is obvious that if one wishes to simulate an aircraft that he must allow the plates to attach to the fuselage (i.e., the prolate spheroid). However, the diffractions associated with the junction formed by the spheroid and flat plate are not well understood. In fact, this topic will be addressed under our follow-on contract with the NASC. Once the junction problem is resolved, one can begin to simulate complete aircraft structures. At that point, the complete numerical solution will be verified in terms of comparing our results with the numerous experimental patterns taken at various organizations in order to verify our previous computer codes.

REFERENCES

1. P. H. Pathak, N. Wang, W. D. Burnside and R. G. Kouyoumjian, "A Uniform GTD Solution for the Radiation from Sources on a Convex Surface," Report 711305-3, February 1980, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract N00019-78-C-0524 for Naval Air Systems Command.
2. W. D. Burnside, M. C. Gilreath, R. J. Marhefka and C. L. Yu, "A Study of KC-135 Aircraft Antenna Patterns," IEEE Trans. on Antennas and Propagation, Vol. AP-23, No. 3, May 1975, pp. 309-16.
3. C. L. Yu, W. D. Burnside and M. C. Gilreath, "Volumetric Pattern Analysis of Airborne Antennas," IEEE Trans. on Antennas and Propagation, Vol. AP-26, No. 5, September 1978, pp. 636-641.
4. W. D. Burnside, N. Wang and E. L. Pelton, "Near-Field Pattern Analysis of Airborne Antennas," IEEE Trans. on Antennas and Propagation, Vol. AP-28, May 1980, pp. 318-327.
5. W. D. Burnside, "Analysis of On-Aircraft Antenna Patterns," Report 3390-1, August 1972, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract N62269-72-C-0354 for Naval Air Development Center. (AD 777989)
6. C. C. Huang, N. Wang and W. D. Burnside, "The High-Frequency Radiation Patterns of a Spheroid-Mounted Antenna," Report 712527-1, March 1980, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract N00019-80-C-0050 for Naval Air Systems Command.
7. H. Chung, W. D. Burnside and N. Wang, "The Near Field Radiation Patterns of A Spheroid-Mounted Antenna," Report 712527-2, November 1980, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract N00019-80-C-0050 for Department of the Navy.
8. "Radiation From a Spheroid-Mounted Antenna in the Presence of a Flat Plate," Report 712527-3, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; to be published.

